

## SOLO-TREC FUNDING AND RESEARCH HISTORY

January 14, 2010

### JPL Research and Technology Development (FY'05-'06-'07)

JPL provided initial funding with internal R&TD funds to allow the design, fabrication, and testing of phase-change-materials (PCMs) that allow an autonomous underwater vehicle to fill a pressurized external bladder, thus controlling buoyancy of that vehicle. JPL experimented with various types of heat and mass transfer systems and decided to use pentadecane paraffin PCM, which expands about 13% when heated above about 10°C, and correspondingly contracts when cooled below 10°C. This expansion/contraction pressurizes hydraulic oil so that it can be used in an external bladder to control buoyancy. The tests confirmed the principle of the Webb Slocum Thermal Glider (U.S. Patent #5,291,847) that ocean thermal temperature gradients can provide all the power needed to control buoyancy of an AUV.

The JPL work went beyond the Webb patent, however, in that improved heat and mass transfer systems were developed (Figure 1), and a novel means of generating the AUV's entire required electricity was developed and patented (Jack Jones and Yi Chao, Caltech Provisional Patent #CIT-4623, 2006). In this design concept, the high pressure oil that is produced by the PCM is stored in a high pressure bladder, and then passed through a hydraulic turbine to produce electricity (Figure 2).

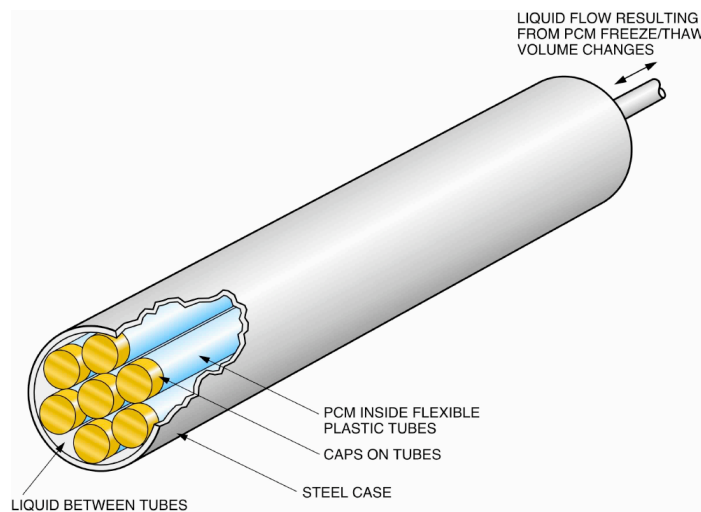


Figure 1. JPL R&TD Test Configuration for PCM Generation of High Pressure Oil

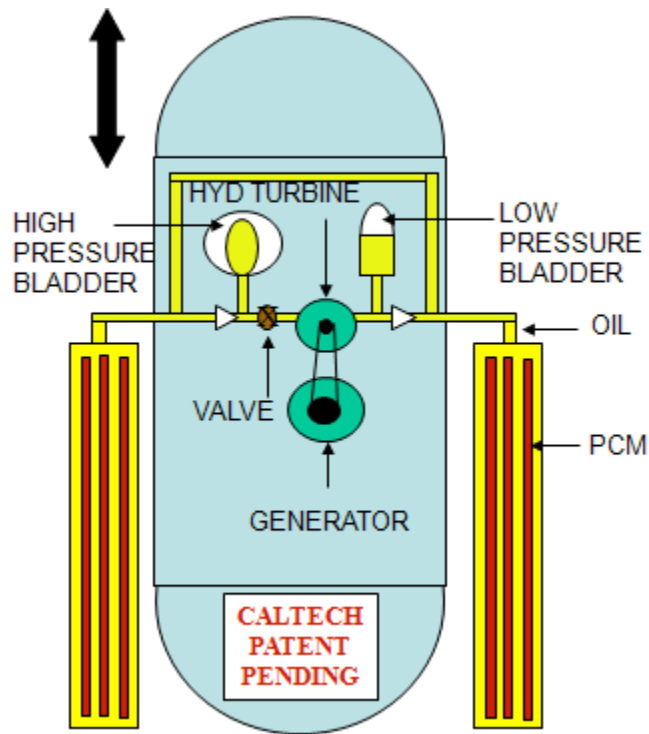


Figure 2.

Pressurized Liquid Oil from PCM Expansion Can Generate Electricity (Caltech Patent Pending)

#### **ONR Funding (FY'08-'10)**

ONR funded the further development of the PCM generated electricity in FY'08-'09, which culminated in an endurance test of the device off the coast of Hawaii starting on November 30, 2009. The AUV internal power unit and the ten external PCM tubes were fabricated by JPL, and the external pressure casing and buoyancy control system was fabricated by Scripps Institution of Oceanography (Figure 3).

The unit continues to make about as much electricity as it consumes, and has operated completely successfully with about 3 dives per day for many weeks. It is expected to last much longer than the 3-month design life, and may, in fact, continue to operate for years to come. All required power is generated solely by using temperature differences in the ocean.

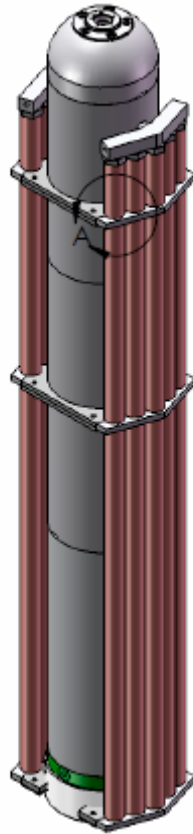


Figure 3. Two-meter Tall PCM-Powered AUV Fabricated by JPL and Scripps